COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS

GUIDE TO THE HIGHWAY GEOLOGY

from

HARRISBURG TO BALD EAGLE MOUNTAIN

by

BRADFORD WILLARD, R. C. CONLIN
and
D. M. HOSKINS

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GUIDE TO THE HIGHWAY GEOLOGY FROM HARRISBURG TO BALD EAGLE MOUNTAIN

By

Bradford Willard, Richard Conlin, and Donald Hoskins

INTRODUCTION

This field trip guidebook is presented as an educational aid in geology primarily for the use of science teachers, but it also includes information of interest to the professional geologist. Discussion includes stratigraphy, structure, and physiography of a well exposed cross-section through the Folded Appalachians. The trip starts at Harrisburg and proceeds through the Appalachian Mountains along the Susquehanna and Juniata rivers to Lewistown; then north to State College by way of Penn Valley. From State College the route crosses the Nittany Valley and ends on top of Bald Eagle Mountain.

PHYSIOGRAPHY

The physiography of Central Pennsylvania is separable into several types, summarized in Table 1. The entire area crossed in this tour is south and southwest of the known limit of Pleistocene glaciation, but extraglacial or periglacial effects are common along the rivers.

Peneplanes

A number of concordant land surfaces (peneplanes) are recognized in Pennsylvania. The following descriptions call attention to surfaces readily distinguished.

Schooley or Kittatinny Peneplane

The Schooley or Kittatinny peneplane is believed to represent the base leveling of the ancestral Appalachians produced after the Appalachian Revolution (Plate 1, A). Following that orogeny came general leveling of the entire surface. Renewed uplift succeeded quiescence. With uplift and stream rejuvenation, the roots of the older mountains were etched out by tributaries, but master streams, the Juniata and Susquehanna, kept their courses and cut water gaps impartially across strong and weak rock. The present plateau and concordant crests of the ridges are interpreted as remnants of the ancient surface.

Harrisburg Surface

The Harrisburg surface is believed to be coincident with the shale surface of the northern part of the Great Valley section. This surface is well displayed in the concordant hilltops of the Lebanon and Cumberland valleys.

A. View north from Harrisburg of the Susquehanna Water Gap. The level summits of the mountains represent the Schooley Peneplane.

B. Little Mountain fault at Stop 2. This is seen at the top of the high quarry face. The bag rests on the slickensided and truncated Montebello sandstone.

TABLE 1, PHYSIOGRAPHY

Major Division	Province	Section	Distribution and Character
Appalachian Highlands Division	Appalachian Plateaus Division	Allegheny Mountain	Northwest of Bald Eagle Valley along the eastern edge of Allegheny Plateau. Mature, plateau topography, moderate relief, some low mountains due to erosion of open folds.
	Ridge and Valley Province	Ridge and Valley	Broad band of closely folded mountains in arcuate pattern north and northeastward between Bald Eagle Creek Valley on the northwest and Kittatinny Mountain on the southeast. Second cycle mountains etched out of folded strong and weak strata, even-crested ridges and parallel valleys.
		Great Valley	From Kittatinny Mountain south to vicinity of Steelton. Low-lying region of mature topography underlain in its northern part by shale, in the south by limestone. The limestone area is slightly lower than the shale. Small, local ridges and knolls in the shale area.
	Piedmont Province	Triassic Lowland	A narrow belt south of Steelton. Low-lying region of red sandstones and shales. To the south, relief is broken by hills supported by basic igneous intrusives.

Drainage

The master stream of central Pennsylvania is the Susquehanna River. From Sunbury south, the main Susquehanna course is fairly direct, passing through miles of water gaps and intervening open valleys. The Juniata River, principal tributary of the Susquehanna, rises in the southcentral part of the State and takes a zigzag course southeastward to join the Susquehanna above Harrisburg. Although it traverses a number of water gaps, the smaller stream is diverted here and there for a few miles along intermontane valleys.

GEOLOGIC HISTORY

The sedimentary rocks which are seen along the highway accumulated over a period of some 250 million years. To discuss intelligently the history and general

relations of these rocks, it is necessary to outline briefly the principles governing the subdivision of these rocks by geologists.

Geologic time is subdivided into eras, which are in turn broken down into successively smaller time divisions known as periods, epochs, and ages. These divisions, names applied to the rocks of each division, and typical examples are given below:

TIME	ROCKS	EXAMPLES
Era	Sequence	Paleozoic
Period	System	Silurian
Epoch	Series	Niagaran
Age	Stage	Clintonian
	Group	Clinton
	Formation	Rose Hill

The age of the earth has been estimated to be about four billion years, but rocks along the highway are those belonging to the Paleozoic Era and were deposited between 250 and 500 million years ago. Old though they are, the rocks occupy a relatively recent chapter in the entire geologic history of the earth. Figure 1 is a geologic time chart which shows the major subdivisions of geologic time and their estimated durations. Figure 2 shows stages in the geologic development of the rocks in Pennsylvania.

GEOLOGIC STRUCTURES

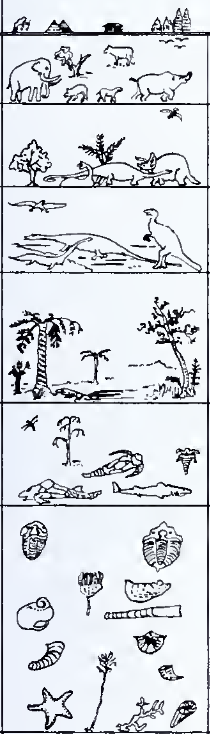
Plate 2 is designed to give a generalized continuous cross-section of the structures seen and crossed from Harrisburg to Bald Eagle Mountain. Although the sections do not necessarily coincide precisely with the route, they include all the major structures.

Folding

In general the structure of the entire trip is dominated by Appalachian type folding. It is obscured from Harrisburg to the Susquehanna Water Gap in Kittatinny Mountain due to low relief and absence of prominent competent beds which can be identified and traced out or tied to the topography. A few glimpses of the minor structures are seen along the route from Harrisburg to the Gap.

From the Gap northward the strike is at first nearly east-west, then changes to northeast-southwest. The folds are comparatively broad anticlines and synclines, with subsidiary tight folding. Many of the axes plunge east or west, northeast or southwest. Cove Mountain is an instance. On the other hand, some remarkably persistent folds are delineated in such long, uninterrupted ridges as Tuscarora and Bald Eagle Mountains. The plunging of so many of the folds gives a zigzag pattern to the topography and areal geology.

GEOLOGIC TIME SCALE



MILLIONS OF YEARS AGO	LIFE RECORD	AGES	GEOLOGIC NAMES	
1		AGE OF ICE AND MAN	QUATERNARY	CENOZOIC ERA
			CASCADIAN REVOLUTION	
60		AGE OF MAMMALS	TERTIARY	
			LARAMIDE REVOLUTION	
120		AGE OF CHALK AND REPTILES	UPPER CRETACEOUS LOWER CRETACEOUS	MESOZOIC ERA
170		AGE OF REPTILES	JURASSIC TRIASSIC	
			APPALACHIAN REVOLUTION	
260		AGE OF COAL AND AMPHIBIANS	PERMIAN PENNSYLVANIAN MISSISSIPPIAN	PALEOZOIC ERA
370		AGE OF FISHES	DEVONIAN SILURIAN	
450 540		AGE OF INVERTEBRATES	ORDOVICIAN CAMBRIAN	
			KILLARNEY REVOLUTION	
4000		AGE OF LOWEST INVERTEBRATES AND ORIGIN OF EARTH	PROTEROZOIC ERA ARCHEOZOIC ERA	PRE-CAMBRIAN TIME

FIGURE 1.

From the Water Gap through Seven Mountains, the ridges and valleys are narrow, compressed, and crowded together. Some of the ridges, such as Half Falls Mountain, are anticlinal. Upon entering Centre County, the valleys open widely. The great, broad anticlinal valleys floored with Lower Paleozoic limestones are rimmed by Ordovician and Silurian limestones, sandstones, and shales.

Faulting

Faulting occurs throughout the area but the visual effects of the movements are not so apparent as is the folding. Attention is called to possible movement between Kittatinny and Little Mountains (Plate 1, B) and to the Perry County thrust on the south flank of Half Falls Mountain. Although these two major faults are the most noticeable along the route, other minor faults may be seen in outcrop or may be shown in the diagrammatic cross sections (Plate 2).

STRATIGRAPHY

The Paleozoic sediments in Pennsylvania were deposited in the Appalachian geosyncline. This was a northeast-southwest trending seaway whose position is now occupied by the Appalachian Mountains. It was bounded on the east by a land source area. Material from that region spread seaward to be deposited as successive layers on the bottom of the subsiding geosyncline. Changes, repetitions, and shifts are recorded in the sedimentary rocks now exposed in the mountains and plateaus.

To discuss fully the Paleozoic stratigraphy along the main route of this tour would amass a far larger volume of description than is warranted. There are, nevertheless, certain phases of the stratigraphy which should be mentioned briefly, because the Paleozoic rocks display them to advantage. This is particularly true of changes of strata between the lower Juniata and Susquehanna Valleys and the State College region. With the geologic column available (Table 2), these Paleozoic variations are readily noticeable.

Ordovician

One of the most apparent changes in the Ordovician along the route is the great variation in thicknesses of the Bald Eagle and Juniata formations. At Susquehanna Gap the Bald Eagle is 28 feet thick and the Juniata is 85 feet thick, while in Central Pennsylvania, especially noticeable in Kishacoquillas Gap, the Bald Eagle thickens to 600 feet and the Juniata is approximately 1,500 feet thick. Generally, these formations thicken westward and northwestward, indicating a westward migration of the center of deposition.

Silurian

In the Lower Silurian, the general thickening northwestward from Susquehanna Gap continues and the Tuscarora and Clinton sediments are better developed in Central Pennsylvania. The persistency of the Keefer sandstone, which is a thin unit, is striking. At Susquehanna Gap, it is possibly 15 feet thick and occurs in a series of sandstone benches separated by shaly units. This same association can be seen

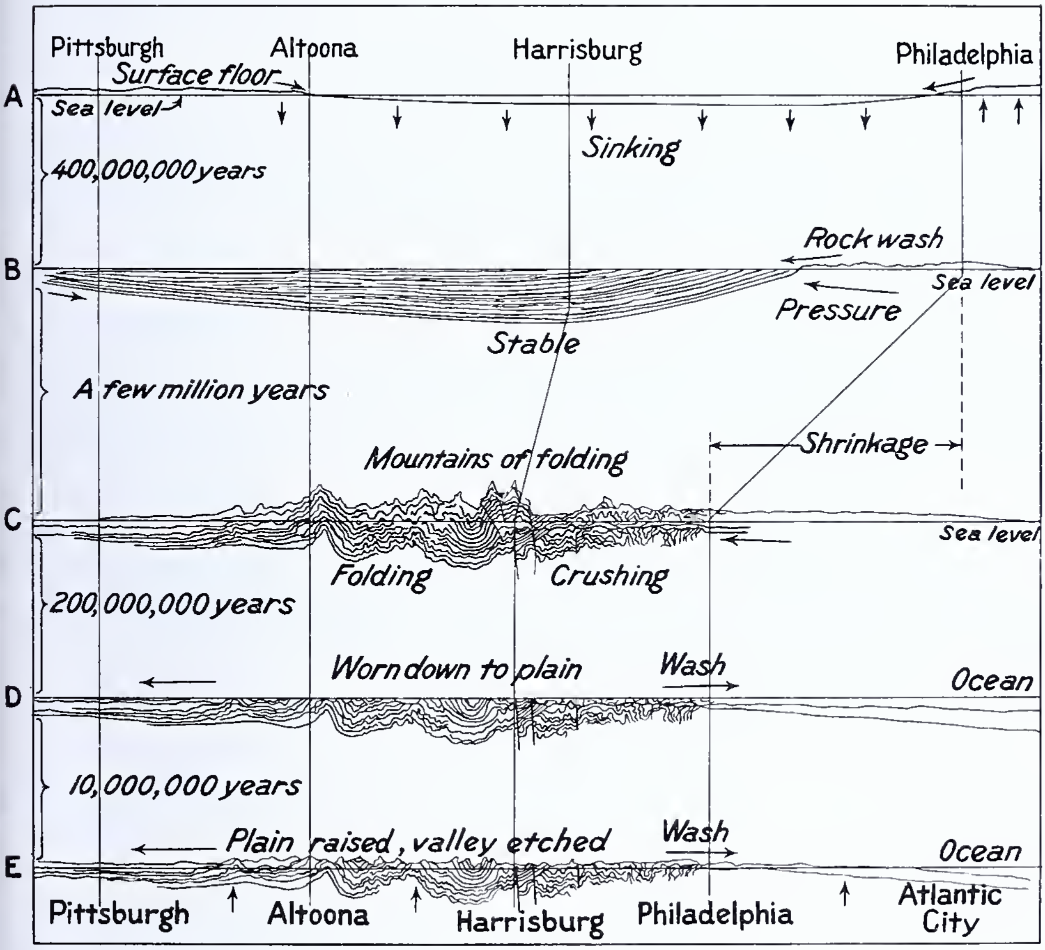


FIGURE 2. SKETCH SHOWING STAGES IN THE GEOLOGIC DEVELOPMENT OF PENNSYLVANIA.

at Mifflintown(STOP VI) where the Keefer is approximately 30 feet thick and still maintains the bench forming peculiarity.

The McKenzie at Mifflintown is also well developed whereas at the Susquehanna Gap it is not nearly so limy if present at all.

Devonian

The Devonian system includes several stratigraphic shifts that are easily appreciated during the tour. Comparison is recommended between the columnar sections for the lower Juniata Valley and for the Bald Eagle Valley.

Note how the Hamilton group changes. In the Susquehanna-Juniata Valleys, the Hamilton consists of black and grayish-brown shales with a great thickness of sandstone, but to the northwest the sandstones disappear in the sequence and the whole section becomes shaly. Evidently, local sandstone was deposited in the Juniata Valley during early and middle Hamilton time.

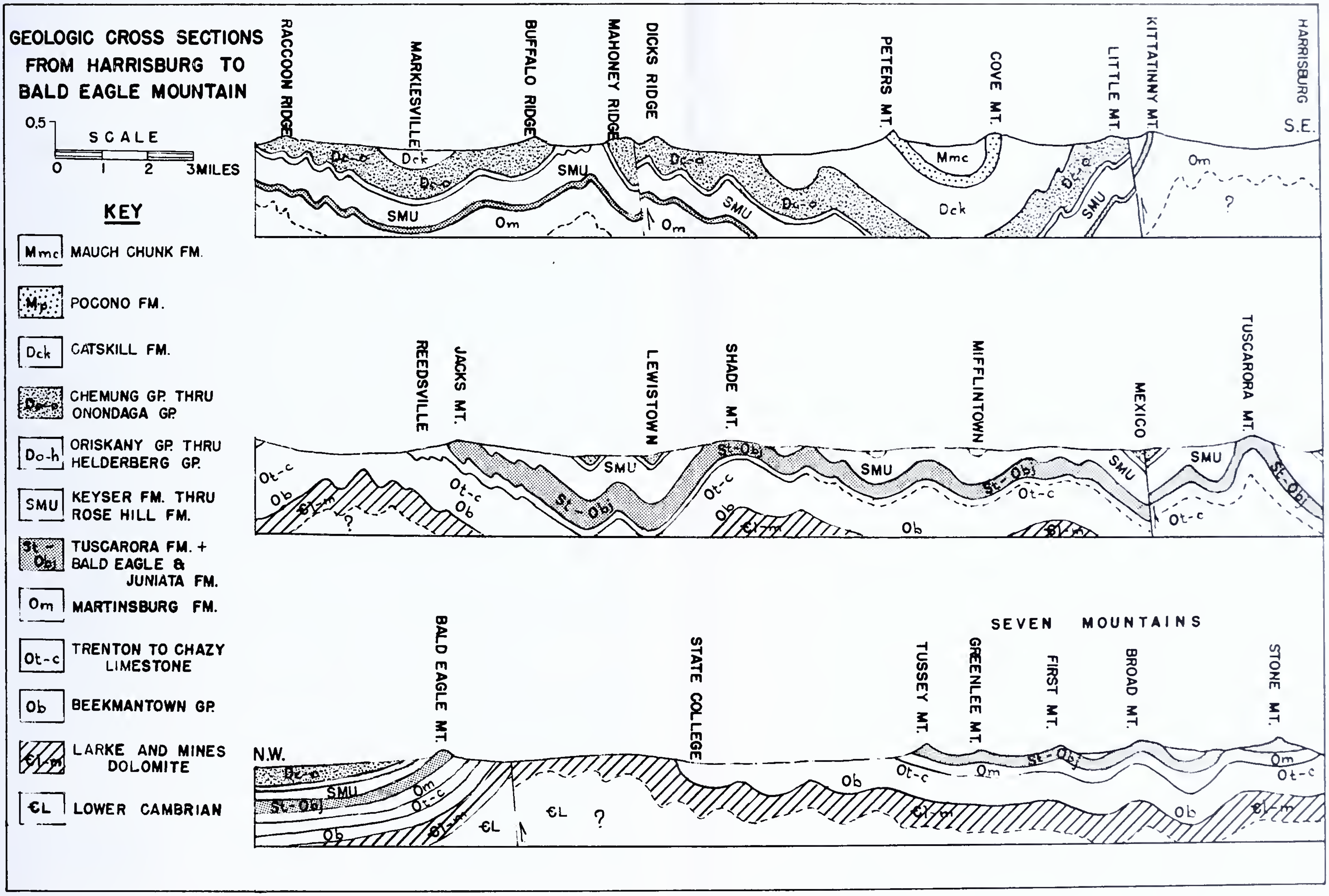
The shift of the Portage is even more striking than that of the Hamilton. In the Juniata Valley, and in fact in all sections east of the Juniata, the marine Portage group is dominated by 1,500 feet or more of the Trimmers Rock sandstone. But, at the Allegheny Front, the group has lost practically all of its sandstone and has become shale, dominated by the thick Brallier which is the stratigraphic correlative of the Trimmers Rock.

PALEONTOLOGY

For those who may wish to collect fossils at the regular stops and other outcrops noted in the itinerary, three plates of fossil pictures are included in the guidebook. One plate each is devoted to the common fossils of the Ordovician, Silurian, and Devonian periods, since these periods include the great majority of the rock formations visited or seen. At a few stops where it is known that fossils are present in appreciable quantities, this fact is noted in the itinerary.

On the page opposite each fossil plate, the range in geologic time in Pennsylvania of the fossil is listed with it's generic name. To determine the geologic age of a rock formation listed in the itinerary, consult the Geologic Column. Examine the fossil plates for the fossils whose range in time includes this formation. Then compare whatever fossil specimens are collected with the fossil pictures to learn it's generic name. When comparing a fossil with the line drawings, remember that some of the drawings are enlarged or reduced in size. The amount of reduction or enlargement is indicated by the number following the times sign, i.e. X.2, X.7, found on the plate explanations.

Not all the fossils are figured that are to be found in the rock formations visited. To do this would require a publication many times the size of this guidebook. It is hoped that most questions of fossil identification will be answered by figuring the common fossils of the three periods.


GEOLOGIC CROSS SECTIONS FROM HARRISBURG TO BALD EAGLE MOUNTAIN
0.5
SCALE
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KEY
Mmc MAUCH CHUNK FM.
Mp POCONO FM.
Dck CATSKILL FM.
Dc-o CHEMUNG GP. THRU ONONDAGA GP.
Do-h ORISKANY GP. THRU HELDERBERG GP.
SMU KEYSER FM. THRU ROSE HILL FM.
St-Obj TUSCARORA FM. + BALD EAGLE & JUNIATA FM.
Om MARTINSBURG FM.
Ot-c TRENTON TO CHAZY LIMESTONE
Ob BEEKMANTOWN GP.
Єl-m LARKE AND MINES DOLOMITE
ЄL LOWER CAMBRIAN
RACCOON RIDGE
MARKLESVILLE
BUFFALO RIDGE
MAHONEY RIDGE
DICKS RIDGE
PETERS MT.
COVE MT.
LITTLE MT.
KITTATINNY MT.
HARRISBURG
S.E.
REEDSVILLE
JACKS MT.
LEWISTOWN
SHADE MT.
MIFFLINTOWN
MEXICO
TUSCARORA MT.
BALD EAGLE MT.
STATE COLLEGE
SEVEN MOUNTAINS
TUSSEY MT.
GREENLEE MT.
FIRST MT.
BROAD MT.
STONE MT.
N.W.

PLATE 2.

TABLE 2. Composite Geologic Column.

System	Series	Subdivisions of Strata	Thickness: Juniata Valley	Thickness: Lewistown	Thickness: State College	General Character of Strata
Pleistocene			Variable			Unconsolidated fluviatile sediments along river valleys; chiefly as terrace gravels, sands, etc.
Pennsylvanian		Allegheny	----	----	150-300	Shale and sandstone with some limestone and coal present.
		Pottsville	0-50	----	0-200	Light-gray conglomerate and sandstone. Some coal may be present.
Mississippian		Mauch Chunk	2000-3000	----	0-30	Series of red shales and sandstones.
		Pocono	1500	----	1100	Gray and greenish-gray sandstone with a few red bands, and black shales. Some local coals may be found.
Devonian	Upper	Catskill	4500-5000	----	1600-2000	Red sandstones and shales with some gray to greenish-grey sandstones and occasional conglomerate.
		Chemung	10-15	----	3000	Gray, brown-weathering sandstones and shales with occasional conglomerate. Fossils usually abundant.
		Portage				The Portage consists of brown and gray to black shales and sandstones with the Tully limestone at base. The Parkhead is a chocolate-brown to purplish, flaggy sandstone unit. Trimmers Rock is mainly flaggy, fossiliferous sandstone. Losh Run is greenish-gray, non-fissile shale with many fossils. Brallier and Harrell are greenish-gray, slightly fossiliferous shales with some sandstone beds. The Burket is a black, fissile shale resembling the Marcellus.
		Parkhead	50	----	----	
		Fort Littleton				
		Trimmers Rock	1600	----	----	
		Losh Run	10	----	----	
		Brallier	220	----	1500	
		Harrell	125	----	150	
		Rush				
		Burket	200	----	50	
		Tully	10	----	10-30	
	Middle	Hamilton				
		Mahantango			600	Massive- to thin-bedded grey to tan sandstones interbedded with vari-colored shales. The Moscow is an extremely fossiliferous shale unit. The Marcellus is a black, fissile shale. Locally there are prominent sandstone members.
		Moscow	50	----	----	
		Montebello	900	----	----	
		Marcellus	50	----	100	
		Onondaga				
		Selinsgrove	100	----	125	Selinsgrove black to dark-gray, medium-bedded limestone at top and grey to greenish-grey Needmore at base.
		Needmore	50-100	----	----	
	Lower	Oriskany				Consists of white to bluish-gray calcareous (Ridgeley) sandstone, and blocky, grayish black, impure cherty limestone (Shriver). Both units contain abundant fossils.
		Ridgeley	5-40	65	100	
		Shriver	0-60	100-125	75	
		Helderberg				The Helderberg consists of local black fissile shale (Mandata), impure, medium-bedded, cherty limestone (New Scotland) and grey to blue, in part crystallized, thick-bedded limestone. (Coeymans)
		Mandata	----	44	----	
		New Scotland	15-65	10	----	
		Coeymans	0-25	6	----	
Silurian	Upper	Keyser	0-180	200	----	Thin- and thick-bedded, dark- to light-grey limestone. Nodular in part. Highly fossiliferous.
		Tonoloway	0-500	500	400	Slabby, thin-bedded, ribbon limestone. Light-gray to gray with shaly beds.
		Wills Creek	0-600	500	400	Light greenish-gray shale with inter-bedded red shale members, and occasional sand and limy zones.
		Bloomsburg	350	330	0-100	Red shale and sandstone with an occasional green bed.
	Middle	McKenzie	200	210	200	Light- to dark-gray limestone and shale. Thin- to medium-bedded. Many fossils.
		Rochester	20-40	28	----	Grey to dark-grey, thin-bedded shale with some interbedded thin limestone. Gradational with Keefer.
		Keefer	20-35	21	----	Medium- to thick-bedded sandstone, grey to whitish, weathers brown to yellow.
		Rose Hill (Clinton)	800	710	800	Ferruginous shales, sandstone with greenish-grey beds common. Limestone commonly occurs in upper part. Fossils abundant.
	Lower	Tuscarora	300	750	400	Light-gray to white sandstone and quartzite with greenish and reddish beds. Some conglomerate present. A ridge-forming formation.
Ordovician	Upper	Juniata	100	1500	1000	Red sandstone, conglomeratic, coarse. Resembles Tuscarora in part.
		Bald Eagle	30	800	800	Coarse, gray sandstone, and conglomerate. Resembles Tuscarora.
		Martinsburg Reedsville*	3000-3500	1000	1000-1200	Dark-gray to black, fissile to non-fissile shale, with some red beds and interbedded sandstone.
	Middle	Trenton				
		Coburn*	----	----	400	Dark-grey to black limestone with interbedded shale in upper part.
		Salona*	----	----	200	Grayish-black fine-grained limestone, with distinctive metabentonite zones.
		Nealmont*	----	----	65	Medium dark-gray limestone with some argillaceous zones in middle.
		Black River	----	----	350	Thick-bedded granular to non-granular gray limestone, with numerous fossil zones. Includes chemical limestones.
		Chazy				
		Loysburg*	----	----	340	Medium-grey limestone, in part laminated. Contains dolomitic and argillaceous zones.
	Lower	Canadian				
		Bellefonte*	----	----	1300	Medium-gray, in part crystallized dolomite with sandstone horizons and containing some chert.
		Axemann*	----	----	375	Grey- to dark-gray limestone, fine-grained to crystalline with thin layers of dolomite.
		Nittany*	----	----	1200	Medium-grey, finely crystalline dolomite with vuggy character in places.
		Stonehenge*	----	----	500	Dark-gray, fine-grained limestone with thin bands of dolomite and beds of limestone conglomerate.
Cambrian	Upper	Mines*	----	----	250	Dark-gray, crystalline dolomite with zones of chert and oolite.
		Gatesburg*	----	----	1500	Dark-gray, finely crystalline dolomite, in part sandy. Produces a sandy soil forming "The Barrens".
		Warrior*	----	----	1000	Medium- to dark-gray, finely crystalline limestone, in part argillaceous and micaceous.

*Divisions recognized in Central Pennsylvania.

GEOLOGIC STRIP MAPS

In the pocket following the last page are the geologic strip maps. These maps, in a somewhat generalized way, show the surface geology along the highway for the entire length of the trip. The maps are intended to show the rock formations that may be found at any point on the trip. As such they will be a useful guide for those who may wish to stop at points for which no discussion is included in the itinerary. They are especially helpful in areas where the soil hides the bedrock. Used with the detailed itinerary, these maps provide orientation of the rock formations and their structures to topographic and man-made features.

ITINERARY

This tour starts from Harrisburg, crosses the Susquehanna River, follows the west bank of that stream to its confluence with the Juniata River. Keeping to the east bank of the Juniata, the route follows the winding valley to Lewistown. Here it leaves the river and turns northward across the valleys and ridges of central Pennsylvania, over Seven Mountains, and into State College. From State College the route proceeds across Nittany Valley and ends atop Bald Eagle Mountain.

Mileage

0.0 Start from zero milepost on Commonwealth Avenue, Harrisburg, behind the State Capitol, facing south.

0.1 Right (west) on Walnut Street, toward the Susquehanna River.

0.5 Bridgehead. Bridge across Susquehanna River.

1.2 West end Susquehanna River bridge. Right (north) on Route 11. West of the highway opposite the bridgehead is a fairly well exposed railroad cut in basal Martinsburg and the underlying Chambersburg limestone.

2.2 Underpass Harvey Taylor Highway Bridge across the river.

3.1 Just south of Conodoquinet Creek, note the good exposure of Martinsburg shale on west side of road.

3.8 Fairview-Enola freight yards of the Pennsylvania Railroad occupy an abandoned channel of the Susquehanna River. The small hill to the northeast across the tracks is supported by a sandstone member in the Martinsburg.

4.4 Cut in Martinsburg.

4.9 Cut in Martinsburg.

5.3 Top of rise, large cut. The Martinsburg shale here carries a few red beds.

5.7 Top of second rise. Once again notice the red horizons in the Martinsburg.

Mileage

6.0 Off to the right side of the road in railroad cut (not visible from the highway) are exposed limy zones interbedded with the Martinsburg shale. These limy zones, together with fossils found near-by led Stose (1946) to believe that this section was older than the underlying part of the Martinsburg. He, therefore, postulated an overthrust.

6.3 Long cut in Martinsburg shale; at south end, a five-foot band of red shale, toward the north end a platy limestone 6 or 7 feet thick.

7.5 Stop I. Susquehanna Water Gap. Park right (east) of highway. View of Susquehanna Water Gap. Across the river, Kittatinny Mountain, the first ridge is underlain and supported by the same strata as seen at this stop. Upper Ordovician and Lower to Middle Silurian resistant formations which support Kittatinny Mountain, cross the river as ledges so prominent at low water that they are referred to as the "Rockville Dam". The beds are nearly vertical, but slightly overturned to the north.

Susquehanna Water Gap exposes an excellent section of Upper Ordovician and Lower Silurian formations. Progressing from south to north:

Traverse (feet)	Thickness (feet)	Name	Lithology
		ORDOVICIAN	
		Martinsburg	Shale, fossiliferous, dark gray to brown, in sharp contact with overlying Bald Eagle.
0	28	Bald Eagle	Conglomerate, with sandston matrix, pebbles up to 3 inche of either quartz, chert, or sandstone. Pebbles angular to well rounded. Some beds ferruginous but generally gra
26	85	Juniata	Sandstone, gray-green, grading into reddish sandston lenticular in occurrence.
		SILURIAN	
113	388 or 441	Tuscarora	Quartzite, gray to white with iron staining and some red members towards base and some conglomerate. Quite massive and resistant be-coming shaly towards top. Contact with Clinton (Rose Hill) gradational.

Mileage

Traverse	Thickness	Name	Lithology
501 or 604	420 or 544	Rose Hill	Interbedded sandstone and shale with quartzite towards base. Becomes shaly in middle and then more sandy with introduction of iron sandstone near the top. Iron sandstone approximately 32 inches thick is practically in contact with overlying Keefer sandstone. Some shaly zones fossiliferous.
1045	8-15	Keefer	Massive, light-brown quartzitic sandstone in two benches each about 6 feet thick with interbedded shale.
		Bloomsburg	Concealed in this section but presence inferred from red soil color.

Return to cars and proceed north to Little Mountain for Stop II.

8.1 Stop II. Little Mountain. Park right (east) before entering large rock cut. Across the highway (west) a valley separates Kittatinny Mountain, from Little Mountain. Although hidden today, it is believed that in this valley Middle Devonian black shale, Marcellus, is in contact with Upper Silurian Bloomsburg red shale. The relationship is better seen across the river at Rockville where only a few feet separate the two. This absence of highest Silurian and Lower Devonian has been ascribed both to faulting and to non-deposition.

Cross highway and walk west along lane at the foot of Little Mountain to a large abandoned stone quarry. Marcellus black shale crops out south in the gully. The quarry exposes the massive Montebello sandstone of the Hamilton group. Ordinarily, the Hamilton group in Central Pennsylvania is dark-gray to black sandstones and shales, but in the Susquehanna-Juniata valleys for some miles north of the Water Gap, the group is largely coarse sandstone and occasional conglomerates. The rock is fossiliferous, chiefly large spirifers. The quarry beds stand almost vertical, base south. Along the top of the quarry a fluted fault surface (not visible from the quarry floor) dips gently to the north. Beneath the fault are truncated beds of Montebello sandstone, above are gently north-dipping sandstone beds similar lithologically to the Montebello but of possibly older age.

Returning to the highway cut, the Montebello may be seen in nearly its entire thickness. Fossils are not abundant and collecting is difficult, owing to the massiveness of the rock. Return to cars and continue north through the cut.

Mileage

8.5 The Portage group is exposed along the railroad, east of the highway, south of Marysville. No Chemung has been identified in this section.

9.0 Marysville. Continue through the village.

9.4 North of Marysville, small cuts expose the red Catskill beds. Across the river, upper Catskill beds form the south flank of Second Mountain. All beds are still slightly overturned north.

10.0 Stop III. Park along right side of highway at south end of stone fence. From this point there is an excellent view of the Susquehanna Gap. The cut at this stop is through the south limb of Cove Mountain which forms a great horseshoe shaped ridge to the west. Across the river, it continues as Second Mountain. The cut exposed the Pocono sandstone (Mississippian) and conglomerate which support the ridge. The beds are overturned as at Stop I.

Northeast across the river is Dauphin Village and beyond it the western tip of Third Mountain, supported by Pottsville conglomerate, basal member of the Pennsylvanian system. This is the extreme western tip of the Southern Anthracite Field. The ridge marks the axis of Cove Mountain syncline. Second Mountain is its southern limb. Peters Mountain its northern limb. Cove Mountain on the west side of the river represents the synclinal nose. The Pocono of Second and Peters is separated from the Pottsville of Third Mountain by valleys cut in the Mauch Chunk red beds (Upper Mississippian). The distant skyline is formed by Peters Mountain. Return to cars.

12.8-13.8 Views of Cove Mountain to west. The Mauch Chunk red beds underlie the lowlands within the cove.

14.7-15.5 Cuts. Mauch Chunk red beds here located at approximate axis of Cove Mountain syncline.

15.5-16.3 North limb of Cove Mountain. At south end of cut the Mauch Chunk interfingers with the Pocono sandstone. A good section of Pocono is exposed in this cut and coaly beds of black shale have been reported from this area.

16.3 Resuming the tour northward, the view across the river of the west end of Peters Mountain shows the Pocono conglomerate on the south passing into the older Catskill red beds on the north. The relations are transitional so that no sharp Devonian-Mississippian boundary is indicated. All beds dip sharply south since they constitute the north limb of the Cove Mountain syncline.

16.5 Crossing Shermans Creek. On the left (west) along the north bank, note south dip slope of Catskill red beds.

A. View looking east across the river at Stop 3 at Second Mountain. The Pocono sandstone causes the ledges in the river.

B. Close folding seen along the Juniata River in the Middle Devonian Losh Run shale at Stop 4.

Mileage

16.6 Duncannon Village.

18.1 Underpass of the Pennsylvania Railroad main line. Cross the Juniata River above its confluence with the Susquehanna.

18.3 Stop Street. Junction of routes 11 and 22. Turn left on Route 22. The highway crosses Haldeman Island, a broad flood plain at the juncture of the Susquehanna and Juniata Rivers. Across river to left, note continuous cuts in Catskill.

20.3 Amity Hall. Intersection routes 22 and 15. Bear left (north) on Route 22 along east bank of Juniata River. The highway is bordered by nearly continuous cuts in lower Catskill red beds.

21.7 The basal Catskill passes gradually downward into fossiliferous marine strata. Although not exposed on the highway, there are at least two higher zones of marine fossils interbedded with the lower Catskill. These fossils have been identified as Chemung in age, and represent a very thin section (10') of Chemung which becomes much thicker to the west.

21.8-22.2 Cut, right (east). The cliff is made up of Trimmers Rock sandstone, principal element in the Portage group in the Susquehanna-Juniata valleys district. Lithologically, the rock is relatively heavy-bedded, medium coarse, gray, brown-weathering, siliceous sandstone.

22.9 Stop IV. Park right (east) in space along highway, 100 yards before road sign "SLIDES", and walk back 200 yards to cut north of gully with lane. This section is lower Portage. At the lane the Losh Run shale crops out. This shale is very fossiliferous and contains easily accessible specimens.

Under the Losh Run shale in the road cut northward is a remarkably closely-folded succession of sandy shale and thin-bedded sandstones. Beyond and below the disturbed strata, the rocks become shalier, and the fauna changes. Greenish shale is the eastward remnant of the Brailler shale of the Allegheny Front. Some of its smooth bedding surfaces are scarred by "worm trails".

Beneath the Brailler the beds change to gray Harrell shale which carries a fauna of small pelecypods and an occasional coiled cephalopod.

Toward the north end of the cut, the Harrell overlies black fissile shale, the Burket. The beds are nearly barren of fossils but toward the base swarm with small pteropods.

At the extreme northern end of the cut, underneath the Burket, the Tully is exposed as a few feet of impure, gray limestone nodules. Moscow shale of the upper Hamilton crops out in contact with the Tully at the northern-most end of the cut. This shale is extremely fossiliferous.

Mileage

Walk past cut beneath cabin to heavy ledges in Montebello sandstone. Continue to shaly zone approximately 100 feet beyond in axis of anticline. This shale is in the Montebello sandstone and is extremely fossiliferous here. Return to cars.

23.0 After passing a small gully, the top of the Montebello sandstone of the Hamilton group rises in an anticline. This is the same sandstone seen in the large quarry at Little Mountain, but its texture is finer. There is little or no conglomerate, and the total thickness has dwindled. Fossils are scarce. The sandstone rises again to the north, this time in a fault block. A prominent thrust, the Perry County fault is responsible for the first ridge south of the main axis of Half Falls Mountain. That mountain is also supported by yet another repetition of the Montebello, this time in an anticline.

23.8 Rubble pit right (east) at foot of talus below the scarp of the upthrust block of Montebello sandstone.

24.0 Stop V. Gravel pit right (east) in terrace deposits. Park and walk north along east side of highway to abandoned road diagonally up bank to the right. About 100 yards from the highway at abandoned limekiln and dump, turn sharp right along deserted tram grade to quarry in the Selinsgrove (Onondagan) limestone. Operation of this quarry ceased about 1932. The quarry was opened in gray, chert-free limestone, almost barren of fossils. The rock dips south as it is in the south limb of the Half Falls Mountain anticline. At the quarry top is the black, fissile Marcellus shale. When the quarry was in operation, the Marcellus-Selinsgrove contact was uncovered. The top of the limestone showed an undulatory erosion surface separated from the shale by a few inches of gray to brown, micaceous sandstone. Still higher above the Marcellus, the Montebello sandstone rises toward the mountain crest. The Half Falls Mountain anticline plunges eastward toward the Susquehanna Valley. Westward in Perry County, beyond the Juniata, the fold opens in a broadening limestone valley.

Continue up the north end of the pit, turn down grade, walk west. The concealed interval beneath the Selinsgrove limestone is underlain by the Needmore shale, also assigned to the Onondaga group. Ridgeley sandstone and conglomerate can be seen on the side of the east-west gully. The Ridgeley dips south. When the leaves are off the trees, it is possible to see across at the north side of the gully the north-dipping Ridgeley beds. The gully marks the approximate axis of the Half Falls Mountain anticline.

Continuing down slope to the highway and entrance to the gully, walk into this depression to its head. The Oriskany overlies Helderberg limestone. The presence of key fossils places the limestone in the New Scotland formation. Note the vertical faulting in the limestone. The fault or faults strike parallel to the axis of the major anticline.

Mileage

26.1- The road passes exposures, first of folded north-dipping Hamilton, then
27.1 Portage. The lower Portage shales are not well exposed, but the Trimmers Rock sandstone is. The highway continues through the Catskill and then back into the Portage.

29.4 The cliffs across the river along the railroad are the type locality of the Trimmers Rock sandstone.

30.4 Note huge quarry in Trimmers Rock sandstone across river.

30.6 Approaching Newport Bridge, notice Portage Catskill contact along east side of the road.

30.7 Newport Bridgehead. Continue north. A long series of cuts expose generally north-dipping Catskill red beds included in the south limb of a large, eastward plunging syncline whose limbs are the converging Buffalo and Berry Mountain ahead.

32.5 Approximate axis of the Buffalo-Berry syncline. Note, first, the flattening of the dip, next the gentle south dip.

36.1 Millerstown square. Intersection routes 22 and 17. The concealed section north of Millerstown is largely underlain by Upper to Middle Silurian units.

37.2 Gap through east end of Tuscarora Mountain which is supported by an eastward plunging anticline of Tuscarora sandstone. Small exposures of this formation can be seen on the right. Road parallels Tuscarora Mountain to the south. Ridges to right are underlain by Marcellus and Montebello.

38.1 Cuts, right (east) in olive-colored shale and thin sandstones, with some reddish shale. These rocks are assigned to the Middle Silurian, Rose Hill.

41.2 Thompsontown Square.

Southwest of Thompsontown, the route crosses relatively flat terrain which is underlain by Wills Creek shale and Tonoloway limestone with a thin cover of river gravel. North of the road along the base of the small ridge, note occasional abandoned limestone kilns or quarries. These indicate the presence of upper Tonoloway and Keyser limestones which were once extensively burned for agricultural use. The ridge beyond the limestone is supported by higher Devonian strata, the local Marcellus sandstones and the Montebello.

47.7 South of Mexico notice across the river the excellent exposure of the dip slope of the Tonoloway, Keyser and Helderberg limestones, and the Oriskany sandstone.

Mileage

48.0 Mexico, the type locality for the Mexico sandstone member of the Marcellus which may be seen at the end of the ridge east of the town. The Marcellus is normally black, fissile shale, but in parts of Perry, Juniata, and Snyder Counties sandy members occur. It is these Marcellus sandstones which support the synclinal ridge eastward.

49.8 The broad open area is underlain almost completely by Middle and Upper Silurian shales, limestones, and sandstones, which fail to crop out.

50.6 West (left) across the river from the high ground south of Mifflintown, on a clear morning, cuts along the river are seen to expose closely folded Wills Creek beds referred to appropriately as "The Rainbow Rocks" (Plate 4,A).

51.2 Mifflintown Square. STOP LIGHT

52.3 Stop VI. Continue through Mifflintown down the grade and park right (east) beside gas station. Walk back up grade to beginning of cut and return down grade observing section which starts with Wills Creek shale.

Thickness (feet)	Name	Lithology
296 (here exposed)	Wills Creek	Interbedded red and green shales.
388	Bloomsburg	Red shale and siltstone with some green shale beds and stringers. Thin calcarious zones present throughout the section.

Cross the stream valley and continue to rear of the gas station.

268	McKenzie	Thin-bedded limestone, dark-gray to black, highly fossiliferous, with some interbedded shale.
98	Rochester and Keefer	These shale and sandstone units are not easily visible here. The Keefer is found at the first road north of the gas station.
	Rose Hill	Interbedded thin- to medium-bedde sandstones and shales, light-gray to brown with highly fossiliferous zones.

Mileage

Comparing this section with that seen at the Susquehanna Water Gap, the thinning of the Bloomsburg towards the west is readily noticeable, and the limy McKenzie is attaining more distinct development. End of Stop VI.

52.8 Right (east), cut behind garage in fossiliferous shale and sandstone belonging to the Rose Hill.

55.7 Entering Lewistown or Juniata Narrows. Gap cuts through the end of Blue Mountain, another great anticline. Right (east) large talus blocks of white sandstone and quartzite derived from the Tuscarora.

56.8 Left, across the river, note dip slope and talus of the Tuscarora formation. The river flows along the axis of a major syncline. On the south side is the long, regular crest of Blue Mountain, on the north Shade Mountain hems in the valley. The Tuscarora is the principal rock in the converging synclinal limbs. Middle Silurian shale lies under the valley bottom.

57.6 Cuts, right. Thin-bedded Middle Silurian sandstones and shales, fissile, gray, brown-weathering, crumpled, of the Rose Hill formation.

58.1 Note cliffs of Tuscarora on right.

59.0 Talus of Tuscarora sandstone and quartzite. Across the river to the south, note the Haws ganister plant using the Tuscarora in manufacturing silica brick.

59.5 Steeply south-dipping Tuscarora.

64.1 Lewistown Square. Right on routes 522 and 322. Continue on routes 522 and 322 via Valley Street to Walnut Street. Turn right on Walnut Street on Route 522. Go one block and turn left on Logan Street.

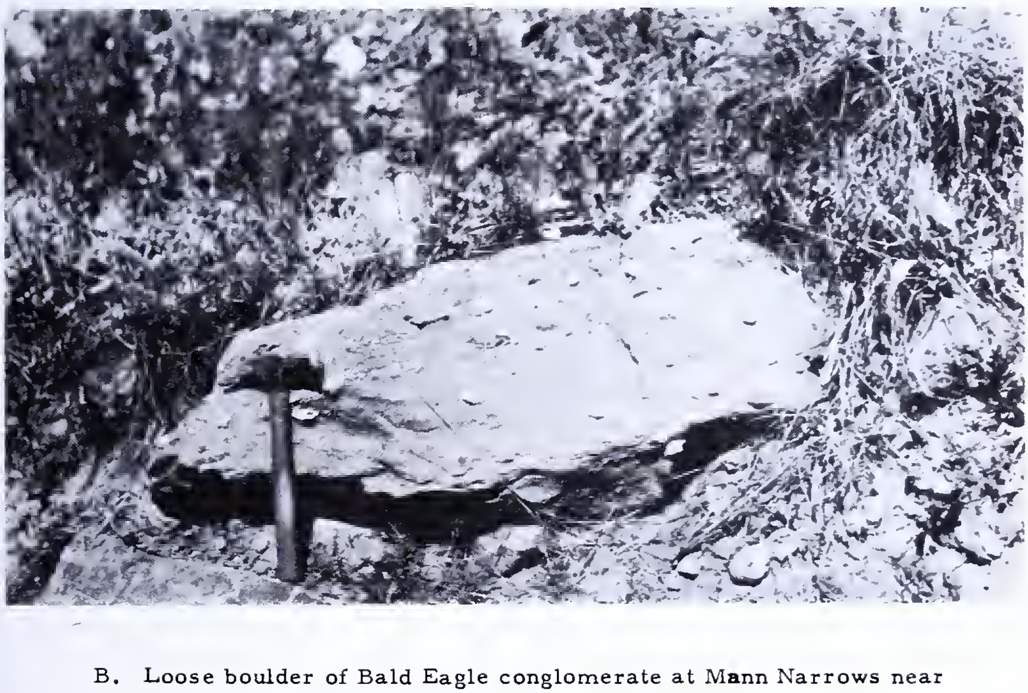
65.1 Beginning of exposure from Hamilton through the Tonoloway. Exposed here are the Hamilton shale, Marcellus shale, Onondaga shale and limestone, Ridgeley sandstone, Shriver chert and limestone, Mandata shale, New Scotland chert and limestone, Coeymans limestone, Keyser limestone, and the Tonoloway limestone.

Cross creek and railroad and bear left.

65.5
Stop VII. Abandoned quarry and lime kiln right of road. The exposure is confined to the Keyser limestone below a few feet of Coeymans at the quarry top. Brachiopods and ostracods occur in the Keyser.

66.0 Right, another abandoned quarry in Keyser limestone. Coeymans occurs at top and possible Tonoloway occurs at extreme base. Note small cave developed in Keyser.

A. Several folds in the Silurian Wills Creek formation as seen from the highway near Mifflintown.



B. Loose boulder of Bald Eagle conglomerate at Mann Narrows near Lewistown.

Mileage

66.3 Small ellipsoidal ridge of Oriskany sandstone. Continue north around end of Big Ridge opposite Mount Rock.

66.8 Dry Valley Road. If time permits a brief visit to a large Ridgeley sandstone quarry approximately one mile along Dry Valley Road is worthwhile. A tramway leads up to the quarry.

67.1 Burnham.

Continue northward via Sixth Street along Steel Plant. At Beech Street, turn left and continue via Edwardon Road to rejoin tour on Route 322 south of Mann Narrows (Kishacoquillas Gap).

69.0 Entering Mann Narrows. Kishacoquillas Creek cuts through Jacks Mountain and exposes an excellent section from the Lower Silurian to the Reedsville.

69.5 Stop VIII. Park to right of highway on old road bed.

At Mann Narrows the Kishacoquillas Creek cuts through Jacks Mountain and exposes an excellent section of Silurian and Ordovician rocks.

Beyond the highway bridge at the east end of the gap, the section continues westward through older and older rocks as follows:

Silurian	Feet
Rochester shale (at easternmost end)	35
Keefer sandstone	55
Rose Hill shale and sandstone	750-800
Tuscarora quartzite	400
Ordovician	
Juniata sandstone and shale	1500-1600
Bald Eagle sandstone and conglomerate	600
Reedsville shale (exposed)	300

At the Stop location, the Juniata is exposed and as one proceeds northward through the gap, the red beds of the Juniata grade into the brownish-gray sandstones and conglomerates of the Bald Eagle. Finally, at the northern end of the cut, the Reedsville shale can be seen.

70.2 Reedsville, type locality of Reedsville shale.

70.3 Intersection of routes 322 and 76. Bear right at fork on Route 322.

70.4 Stop IX. Mill Pond, right. Park between highway and pond. On the west side of the road a cut exposes Salona limestone of the Trenton group. About 20 feet north of road intersection, metabentonite interbedded with limestone, usually spotted by yellowish soil, may be found. On Route 76 immediately

Mileage

northwest of its intersection with Route 322, a long cut exposes the Salona and Coburn limestones. Interbedded with the limestones, at the northern end of the section, are six to eight metabentonite zones.

Driving north, the highway enters Kishacoquillas Valley, a great broad anticlinal valley carved from older Paleozoic limestones. Here and there are outcrops of Ordovician limestones and dolomites. Occasional sink holes in the fields are often revealed by small clumps of trees.

73.6 Road by-passes Milroy.

75.3 Opposite American Legion Building on right side of road, note talus slope. The Bald Eagle is exposed above in cliffs, forms Little Mountain. Beds overturned north and dip south about 75 to 80 degrees, the base to the south.

75.4 Entering Seven Mountains area.

75.6 Juniata red beds, south-dipping, overturned north.

76.3 Cut, right (east). Juniata red beds, dip flattened to about 65 degrees south, but beds are still overturned. Talus derived from the Tuscarora.

77.8 Cut and abandoned quarry. Sheared red and brown shales dip 40 degrees south. Tight folding is present.

78.3 Tuscarora-Juniata contact. Intermittent exposures north.

80.0 Juniata sandstone crop and Bald Eagle boulders which occur as float.

80.6 State Forestry Experiment Station.

81.4 Juniata exposed in long cut. At first dip is north about 22 degrees, but dips change rapidly to south.

81.7 Large talus blocks of pebbly Bald Eagle. This formation supports Little Mountain.

82.3 Cuts in Reedsville shale. Intersection of routes 322 and 53 at Potters Mills. Bear left on Route 322 towards State College.

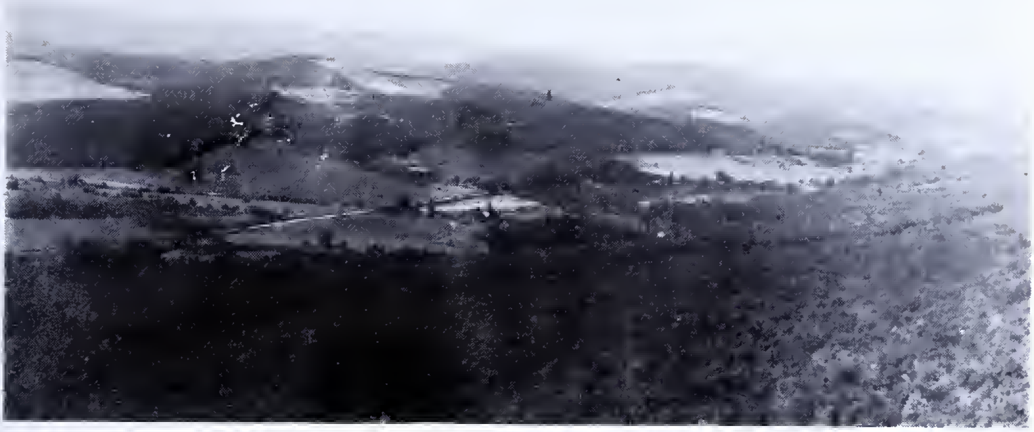
82.9 Trenton limestone, in crest of anticline.

83.2 Reedsville shale. Excellent views through this area of the end of Tussey Mountain syncline on the south and Penn Valley anticlinorium to the north with Nittany Mountain syncline beyond.

86.5 Section of the Nealmont (Trenton) limestone; at McClellan Chrevrolet sign.

Mileage

87.8 & 88.2	Exposures of the Bellefonte showing characteristic weathering features.
90.4-90.6	Note Nittany Mountain plunging out to the east.
92.1	Boalsburg. Turn right on Boalsburg Pike toward Oak Hall.
93.1	Note Trenton limestones, dipping north toward Nittany Mountain syncline.
93.3	Oak Hall. Proceed northward.
94.1	Large quarries on both sides of road. Quarrying has exposed the Trenton and Black River limestones. The Black River is thick-bedded dark-blue limestone and occurs beneath the thin-bedded Trenton limestones.
94.4	Reedsville shale. Note the northwest dip of the shale beds. Within a very short distance the route passes across the axis of the Nittany Mountain syncline and the change of the dip can be seen in the Reedsville shale quarries.
94.5	Reedsville shale. Note the southeast dip of the beds. We have crossed the axis of the syncline and are now on the north limb.
95.4	Lemont. Stop sign. Continue on to State College.
96.1	Intersection with Route 545. Turn left.
96.9	Center Furnace. Used in the 1800's for iron making.
97.1	Limestone outcrop.
97.4	Entering State College. Proceed straight to intersection with Route 322. Turn right.
98.7	Entrance to Pennsylvania State University. Golf course on left.
99.5	Large outcrop of the Stonehenge limestone.
99.7	Railroad crossing. Approximate contact of Stonehenge and Mines formations.
99.7-100.4	Crossing area of Cambrian dolomite (Mines). No good exposures seen but soil carries bits of silicified oolite so characteristically abundant in this formation.
101.4	Entering the "Barrens", a terrain developed on the Cambrian Gatesburg formation which is dominated by impure sandy dolomite. Scrub forest is typical. The soil from the Gatesburg is acidic, low in nutrients, and dries rapidly so that the lands are generally not cultivated.



A. View northeast of the Allegheny Front from the tower on Bald Eagle Mountain. The rocks in the distance are Devonian and Mississippian.

B. Line drawing of the above picture. Mp-Pocono, Dc-Catskill, Dch-Chemung, Dp-Portage.

Mileage

102.6 Exposures of the Gatesburg dolomite and sandstone.

103.4 Warrior limestone, dipping to the southeast.

103.6 Valley at the approximate location of the Birmingham fault.

105.2 Stop X. Walk down grade approximately 300 yards to the black shale outcrop. The section here is as follows:

	Feet
Reedsville shale, fossiliferous	440
Bald Eagle sandstone and conglomerate	330
Juniata sandstone and shale, exposed	1000

Note at this location, which exposes the Upper Ordovician for the last time westward, how the thicknesses compare to those at Susquehanna Gap. The Bald Eagle, which is as thick as 800 feet in the general area has changed drastically from the 30 feet present at Susquehanna Gap. The Juniata has become progressively thicker, also.

105.4 Crest of Bald Eagle Mountain. Park near Tower. Below is spread the Bald Eagle Valley. Beyond rises the Allegheny Front. The picture and line drawings on Plate 5 give the approximate identification of the ridges with the stratigraphic sequence. This marks the junction of the Folded Appalachians and the Allegheny Plateau.

End of Trip.

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APPENDIX

Glossary

Anticline An upfold or arch in rocks in which the beds dip in opposite directions from a common axis.

Argillaceous Term applied to rocks that include a substantial amount of clay in their composition.

Axial plane An imaginary plane that divides a fold so that the limbs of the fold are symmetrically arranged on either side of the plane.

Axis The line formed by the intersection of the axial plane with a bedding surface in a fold.

Base-leveling The reduction of a land surface by erosion to the lowest level possible.

Bed A layer of rock bounded top and bottom by planes of separation. The thickness of a single bed may range from paper thinness to tens of feet.

Calcareous Term applied to rocks that include calcium carbonate in their compositon.

Chemical limestone A rock composed predominately of calcium carbonate, formed through direct chemical precipitation.

Chert A compact rock composed of silica in which grains cannot be seen except with high magnification. Flint is a variety of chert.

Competent bed Competent and incompetent are relative terms. A competent bed is one that is relatively stronger than the beds that enclose it and will deform (fold and/or fault) less than the enclosing beds. An incompetent bed is one that is relatively weaker than the beds that enclose it and will deform more than these enclosing beds.

Confluence The point where two streams meet.

Conglomerate A rock made up of pebbles and/or gravel cemented together.

Cross section A cross section is a sketch portraying an interpretation of the geology under the earth's surface. If one were to cut a slice out of the earth's surface and lift it out, the side of the slice would be a cross section and would show the structure and layering of the rocks.

Dip The angle at which a bed of rock is inclined from the horizontal. The dip is at right angles to the strike.

Dolomite A term applied to those rocks that approximate the mineral dolomite in compostion. The chemical composition is calcium magnesium carbonate.

Extraglacial See periglacial

Fault A fracture zone in a body of rock along which there has been movement on one or both sides of the break. The amount of displacement may be a few inches or many miles.

Ferruginous Containing iron.

Fissile Term applied to rocks that split easily along closely spaced parallel planes.

Flaggy Term applied to rocks that split readily into slabs suitable for flagstone.

Fold A bend in layers of rock.

Formation A mappable bed, or group of beds. A formation must have recognizable contacts which are capable of being traced in the field.

Fossil The remains or traces of animals or plants which have been preserved by natural causes in the earth's crust.

Fossiliferous Containing organic remains.

Genus A group of closely related species of animals or plants. The plural of genus is genera.

Geosyncline An elongate trough of great extent that has received thick sedimentary and volcanic deposits during slow subsidence through a long period of time.

Glaciation Alteration of the earth's solid surface through erosion and deposition of glacier ice.

Group A stratigraphic unit consisting of two or more formations.

Incompetent bed See competent bed.

Intermontane Lying betweeen mountains.

Iron sandstone A term applied to certain sandstone beds in the Rose Hill formation that contain an estimated 5-10% hematite as coatings on quartz grains.

Layer A bed or stratum of rock.

Lenticular Shaped approximately like a double convex lens.

Limb One of the two parts of an anticline or syncline on either side of the axis.

Limestone A bedded sedimentary deposit consisting chiefly of calcium carbonate.

Lithology The appearance, mineral composition, and textures of rock.

Massive Occurring in thick beds.

Metabentonite Altered bentonite. Bentonite is a clay formed by the decomposition of volcanic ash and has the property of absorbing large quantities of water. Metabentonite, because of alteration loses this property.

Micaceous Containing mica.

Non-deposition A term applied to a portion of geologic time in which no sediment was deposited.

Nose (Of a fold) Place on a map where a bed or formation shows the maximum curvature.

Oölite A very small spherical to ellipsoidal body with concentric and/or radial structures, usually composed of calcite but may be siliceous or of other composition.

Orogeny The process of forming mountains by folding and faulting.

Overturned Having been tilted from the horizontal past the vertical. At the time of deposition, beds of rock have nearly horizontal attitudes, and younger beds lie on older beds. Folding may lead to overturned beds that are rotated more than 90 degrees from the horizontal and the result is older beds physically overlying younger beds.

Paleozoic One of the eras of geologic time that, between the Precambrian and Mesozoic eras, comprises the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian and Permian.

Peneplain A land surface worn down by erosion to a nearly flat or broadly undulating plain.

Periglacial Pertaining to a belt of terrain of indeterminate width adjacent to the margin of a glacier.

Physiography Same as physical geography: a description of existing nature as displayed in the surface arrangement of the globe, mountains, valleys, atmospheric and ocean currents, etc.

Plunge The inclination of the axis of a fold as measured in a vertical plane containing the axis.

Resistant Term applied to rocks not easily eroded.

Sandstone A clastic sedimentary rock composed predominately of quartz grains, the grades of the latter being of sand size.

Sedimentary Descriptive term for rock formed of sediment, especially: (1) clastic rocks, as conglomerate, sandstone and shales, formed of fragments

of other rock transported from their sources and deposited in water. (2) Rocks formed by precipitation from solution, as rock salt and gypsum, or from secretions of organisms, as most limestone.

Shale A laminated sediment, in which the constituent particles are predominately of the clay grade size.

Source area Area of land above sea level from which sediments are derived.

Stratigraphic shift Within a stratigraphic unit (formation, group, etc.) the change of the lithology of one area to a different lithology in another area.

Stratigraphy That part of geology which deals with the formation, composition, sequence and correlation of the stratified rocks of the earth's crust.

Striations Fine parallel scratches on the surface of a rock; caused by one rock scratching another.

Strike The direction (azimuth) of a line formed by the intersection of an inclined surface and a horizontal plane.

Structural feature Features produced in the rock by movements after the rock has been deposited, i. e., folds and faults.

Structure The sum total of the structural features of an area.

Syncline A downfold in rocks in which the strata dip inward from both sides toward the axis.

Topography The physical features of an area: The relief and contour of the land, as mountains and valleys.

Vugular Term applied to rocks containing many cavities, usually of small size and usually lined with a mineral incrustation.

EXPLANATION OF PLATES

Ordovician Fossils

Plate 6

Phylum Brachiopoda (lamp shells)

Figure 1. Diparelasma, x 1; a. dorsal view, b. side view; Lower Ordovician

Figure 2. Finkelnburgia, x 1; ventral view; Lower Ordovician

Figure 3. Doleroides, x 1.5; a. posterior view, b. ventral view; Middle Ordovician

Figure 4. Hesperorthis, x 1; a. dorsal view, b. side view; Middle Ordovician to Middle Silurian

Figure 5. Dinorthis, x 1; ventral view; Middle and Upper Ordovician

Figure 6. Valcourea, x 2; dorsal view; Middle Ordovician

Figure 7. Hebertella, x .7; a. ventral view, b. side view; Ordovician

Figure 8. Resserella, x 1; ventral view; Middle Ordovician to Middle Silurian

Figure 9. Rhynchotrema, x .7; a. ventral view, b. side view, c. dorsal view; Middle and Upper Ordovician

Figure 10. Rafinesquina, x .7; ventral view; Middle and Upper Ordovician

Figure 11. Sowerbyella, x 2; dorsal view; Middle and Upper Ordovician

Figure 12. Zygospira, x 2; a. side view, b. dorsal view; Middle Ordovician to Lower Silurian

Phylum Hemichordata, Class Graptolithina (Graptolites)

Figure 13. Climacograptus, x 2; Ordovician

Figure 14. Glossograptus, x 3; Ordovician

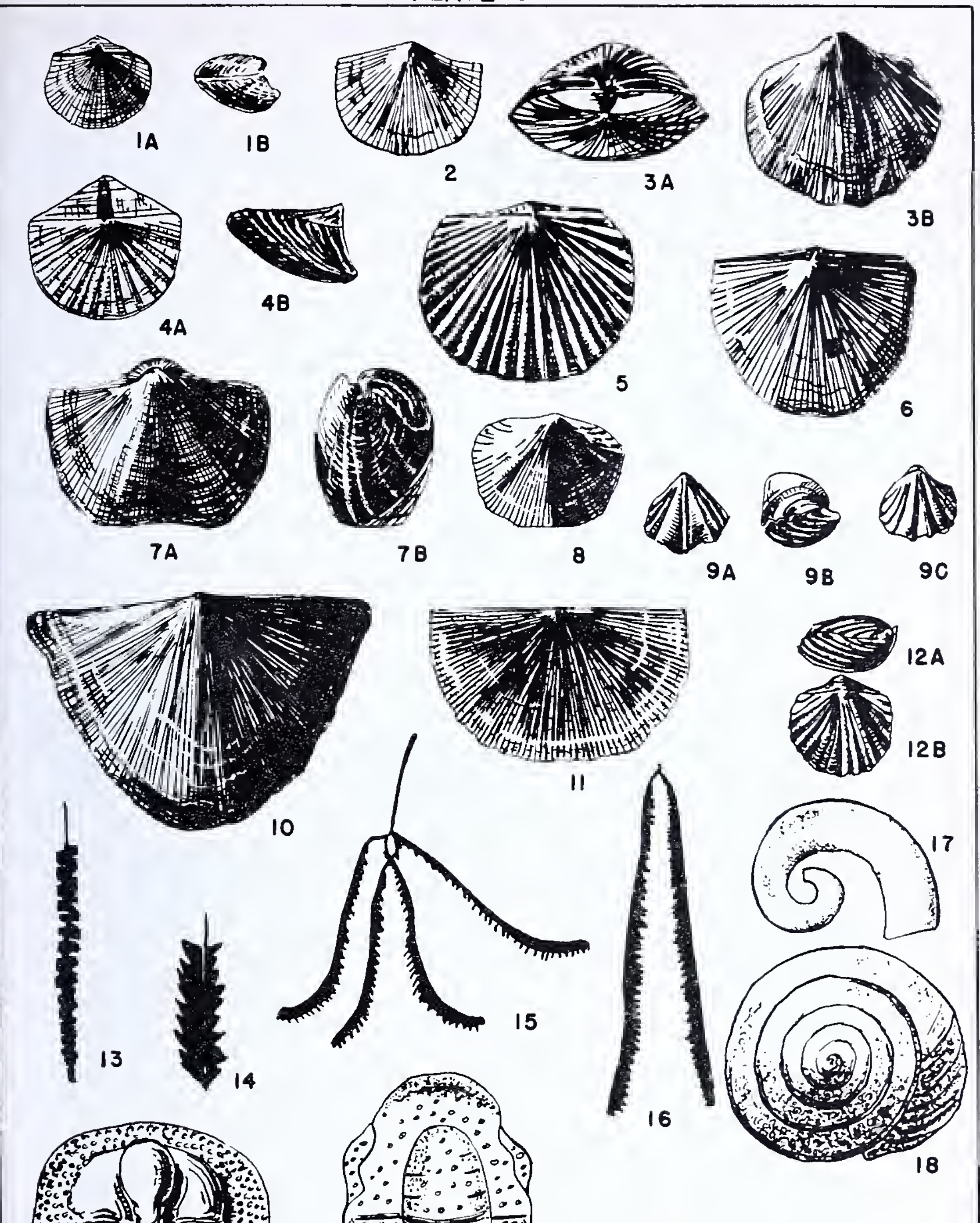
Figure 15. Tetragraptus, x .7 ; Ordovician

Figure 16. Didymograptus, x 5; Ordovician

Phylum Mollusca, Class Gastropoda (snails)

Figure 17. Ecculiomphalus, x 1; Ordovician

PLATE 6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Ordovician Fossils (contd)

Figure 18. Ophileta, x 1; Lower Ordovician

Phylum Arthropoda, Class Trilobita (trilobites)

Figure 19. Cryptolithus, x 1.3; complete specimen; Ordovician

Figure 20. Bellefontia, x .7; pygidium; Lower Ordovician

Figure 21. Hystricurus, x 5; dephalon; Lower Ordovician

Figure 22. Flexicalymene, x 1.5; complete specimen; Ordovician to Silurian

Silurian Fossils

Plate 7

Phylum Brachiopoda (lamp shells)

Figure 1. Rhipidomella, x 1; ventral view; Middle Silurian to Middle Devonian

Figure 2. Rhynchotreta, x 1; a. ventral view, b. side view; Silurian

Figure 3. Leptaena, x 1; ventral view; Middle Ordovician to Mississippian

Figure 4. Fardenia, x .7; a. dorsal view, b. side view; Middle Silurian

Figure 5. Chonetes, x 1.5; ventral view; Middle Silurian to Devonian

Figure 6. Atrypa, x .5; a. dorsal view, b. side view; Middle Silurian to Devonian

Figure 7. Eospirifer, x .7; a. dorsal view, b. side view; Middle Silurian to Lower Devonian

Figure 8. Cyrtia, x .7; a. dorsla view, b. side view; Middle Silurian

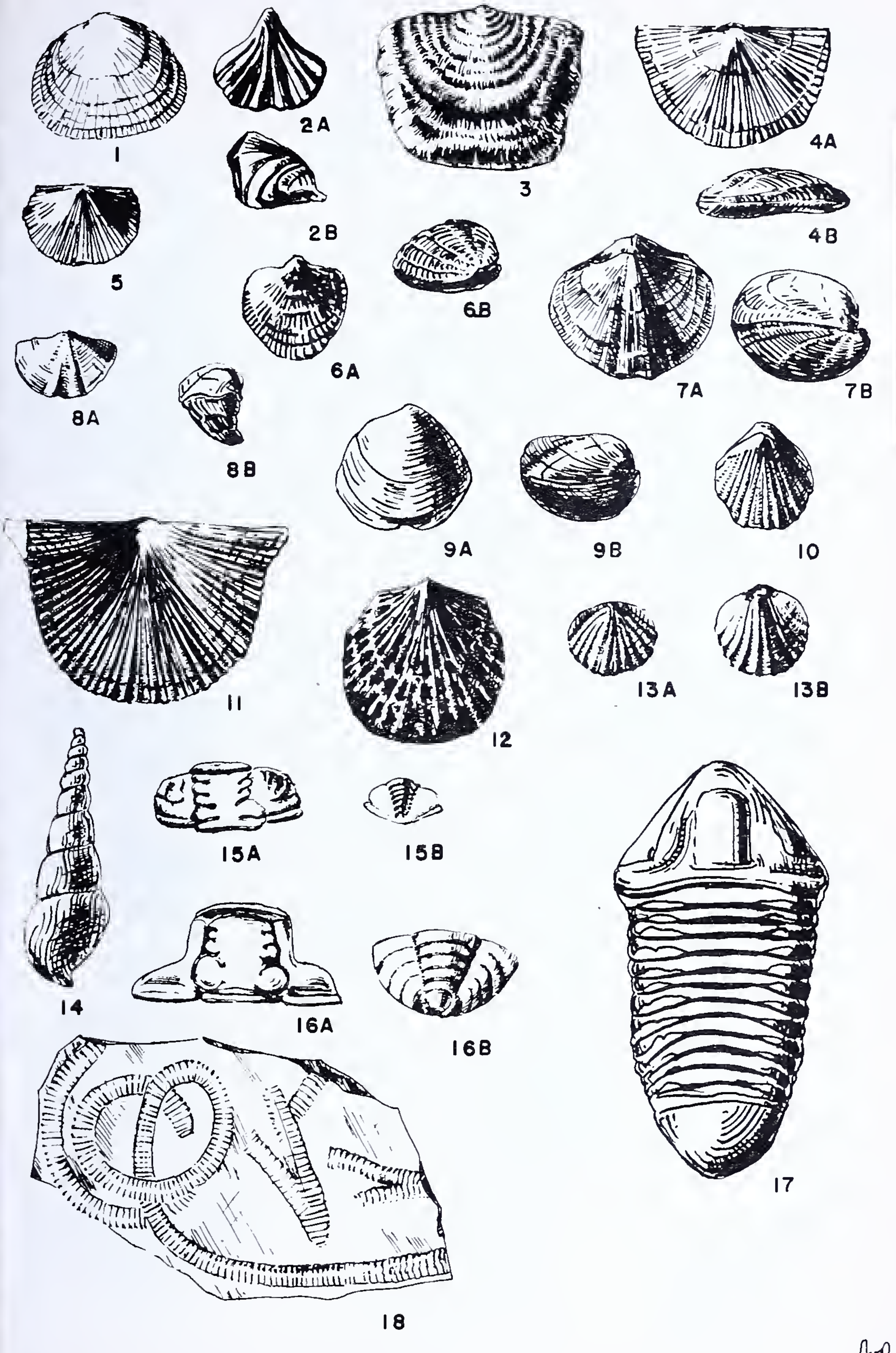
Figure 9. Meristina, x .7; a. ventral view, b. side view; Middle Silurian

Figure 10. Homeospira, x .7; dorsal view; Middle Silurian

Figure 11. Stropheodonta , x 1; ventral view; Devonian

Figure 12. Dalmanella, x 1; ventral view; Lower Silurian

PLATE 7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Silurian Fossils (contd)

Figure 13. Coelospira, x 1; a. dorsal view, b. ventral view; Middle Silurian to Middle Devonian

Phylum Mollusca, Class Gastropoda (snails)

Figure 14. Loxonema, x 1; Ordovician to Mississippian

Phylum Arthropoda, Class Trilobita (trilobites)

Figure 15. Liocalymene, x 1; a. cephalon, b. pygidium; Silurian

Figure 16. Calymene, x 1; a. cephalon, b. pygidium; Silurian to Middle Devonian

Figure 17. Dipleura, x .5; complete specimen; Devonian

Phylum Annelida (segmented worms)

Figure 18. Arthrophycus, x .5; Lower Silurian

Devonian Fossils

Plate 8

Phylum Brachiopoda (lamp shells)

Figure 1. Tropidoleptus, x .7; ventral view; Middle to Upper Devonian

Figure 2. Rensselaeria, x .7; dorsal view; Lower Devonian

Figure 3. Gypidula, x .7; a. dorsal view, b. side view; Lower Devonian

Figure 4. Eatonia, x .7; a. side view, b. ventral view; Lower Devonian

Figure 5. Camerotoechia, x 1; a. dorsal view, b. side view; Silurian to Devonian

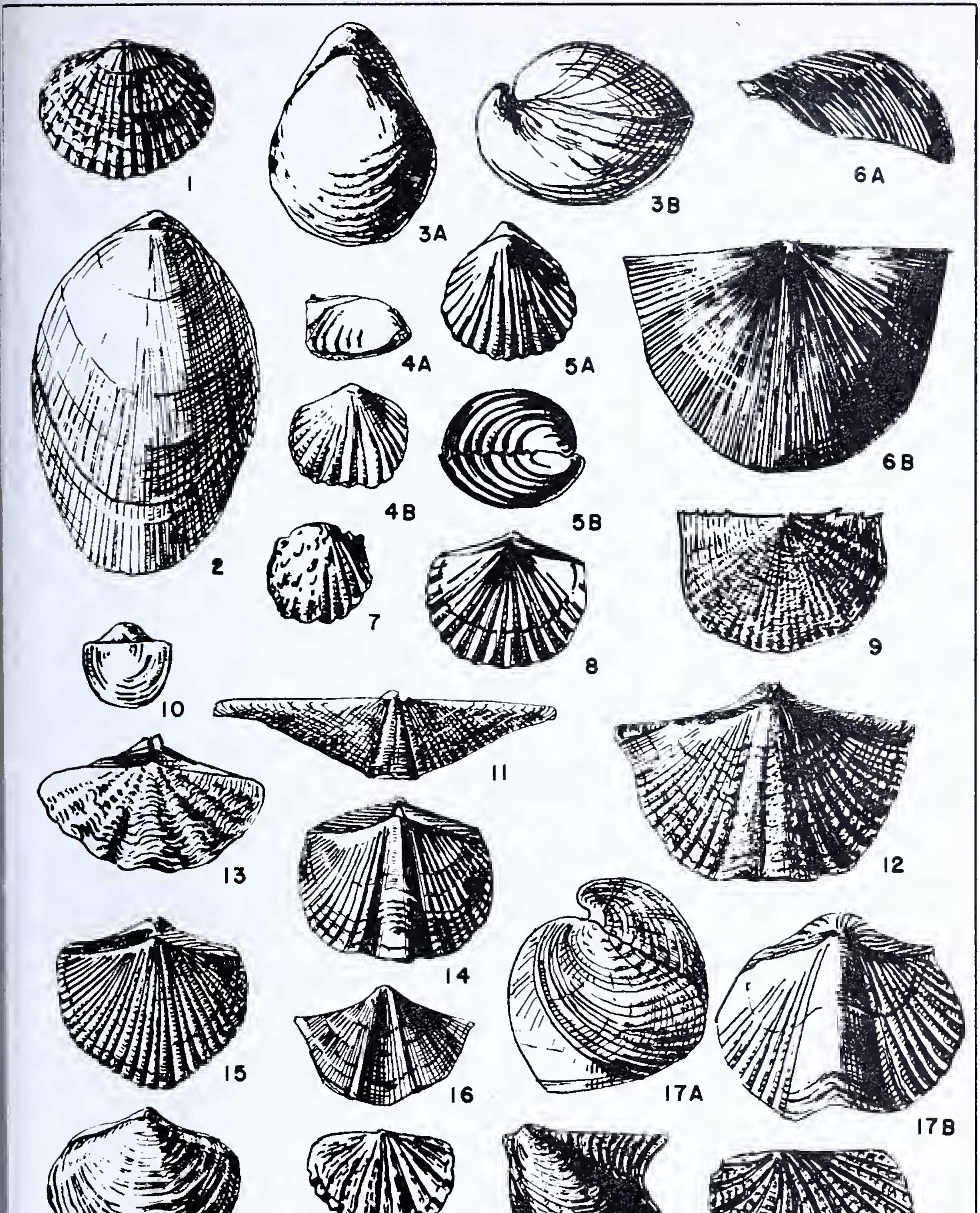
Figure 6. Strophonella, x .7; a. side view, b. dorsal view; Devonian

Figure 7. Productella, x 1; ventral view; Devonian

Figure 8. Leptocoelia, x 1; dorsal view; Lower to Middle Devonian

Figure 9. Chonetes, x 3; ventral view; Middle Silurian to Devonian

PLATE 8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Devonian Fossils (contd)

Figure 10. Ambocoelia, x 1; dorsal view; Devonian

Figure 11. Mucrospirifer, x .7; dorsal view; Middle to Upper Devonian

Figure 12. Spinocyrtia, x .7; dorsal view; Middle Devonian

Figure 13. Delthyris, x .7; dorsal view; Middle Silurian to Lower Devonian

Figure 14. Platyrachella, x .7; dorsal view; Middle to Upper Devonian

Figure 15. Costispirifer, x .7; dorsal view; Lower Devonian

Figure 16. Cyrtospirifer, x .7; ventral view; Upper Devonian

Figure 17. Paraspirifer, x .7; a. side view, b. dorsal view; Lower to Middle Devonian

Figure 18. Athyris, x .7; dorsal view; Middle to Upper Devonian

Figure 19. Pustulina, x 2; dorsal view; Middle Devonian

Phylum Mollusca, Class Pelecypoda (clam shells)

Figure 20. Leiopteria, x .5; left valve; Devonian

Figure 21. Buchiola, x 6; left valve; Silurian to Devonian

Phylum Arthropoda, Class Trilobita (trilobites)

Figure 22. Phacops, x 1; complete specimen; Devonian

Figure 23. Greenops, x 1; complete specimen; Middle and Upper Devonian

Phylum Mollusca, Class Gastropoda (snails)

Figure 24. Loxonema, x 1; Ordovician to Mississippian